Improvements of Indoor Fingerprint Location Algorithm based on RSS

Qiuyue Zhu [a], Qiang Yu [b], Qi Liu [c] and Kun Shi [d]

School of Computer and Software Engineering, Xihua University, Chengdu 610039, China

[a]qiuyue1316@163.com, [b]495356125@qq.com, [c]13032898629@163.com, [d]1252806141@qq.com

Abstract

With the development of the Internet, the technology of location fingerprint is widely used because of the advantage in indoor positioning performance of complex environment. K neighbor algorithm based on signal strength is a common position fingerprint matching algorithm. This paper firstly introduces the KNN fingerprint localization algorithm, and points out the deficiency of the algorithm. Then on the basis of the algorithm, correction K neighbor algorithm is put forward through improved the calculation of Euclidean distance. The simulation results show that the improved correction algorithm can achieve good location accuracy compared to traditional KNN algorithm.

Keywords

Received Signal Strength, Indoor Positioning, Location Fingerprint, KNN Algorithm.

1. Introduction

In recent years, the global positioning system (GPS) [1] and the technology of cellular wireless location has been able to provide a more accurate location service outdoors, and has been applied in many fields such as military, traffic, surveying and mapping. Compared with the outdoor environment, indoor environment is relatively complex, and are more susceptible to interference from the building and the multipath phenomenon because of indoor signal reflection, diffraction, refraction and scattering. The existing positioning technology can't meet the demand of relatively accurate positioning indoor. Therefore, looking for a kind of wireless positioning system which has high precision and good stability become urgent needs in the field of indoor positioning, and the localization algorithm is the key to solve this problem.

Compared with the traditional TOA [3], TDOA [4] and AOA location algorithm, indoor positioning algorithm based on the received signal strength [2] (RSS) don't need to change the hardware equipment, and can realize positioning only by using the existing wireless network resources, so it reduces the cost, and is widely studied. At present, the indoor location based on RSS include locating method based on signal transmission loss model and positioning method based on the position fingerprint. Signal transmission loss method usually depends on that the signal transmission loss in free space is inversely proportional to the square of the distance, because both the influence of the multipath effect and the dependence of the signal propagation model make its accuracy restricted. The location fingerprint positioning technique depends on identifying the signal characteristics of the target location, using the differences of each point signal to realize the localization. So the second method is less affected on the positioning accuracy in the complex indoor environment. However, complex and changeful of indoor environment itself will lead to the volatility of signal strength value as well as the external factors, so we must consider the effective filtering of signal value and quick screening method of processing position fingerprint data from a database to improve the indoor positioning algorithm, so as to improve the accuracy of positioning.

In the traditional fingerprint location algorithm, we would get the final positioning result through by fingerprint matching or mapping using RSS value of the reference nodes. At present, the common fingerprint localization algorithm basically has: the nearest neighbor method (NN), K neighbor

method (KNN), K weighted neighbor method, naive bayes algorithm. This paper bases on KNN algorithm to improve the research.

2. Modified Algorithm

2.1 KNN Algorithm

KNN algorithm improve the reference node number of positioning comparing with the nearest neighbor method. Nearest neighbor method choose the reference position which is the most similar to a locating node at the signal strength vector as the estimate position of the locating position. However, it is not feasible in practice due to the decision in the location node is too large and density requirement of fingerprint acquisition will be very high. The KNN algorithm make up for it by selecting K ($K \geq 2$) fingerprint data as locate reference points. Through calculating and sorting euclidean distance, the K fingerprint data with minimum characterize the general region of the locating position.

Suppose there are n wireless access points (AP) and m reference points (RP) in positioning area. In the offline phase, as shown in Fig. 1, we collect signals in each RP from different AP and preprocess them to establish a fingerprint database. In the positioning stage, we firstly get signal information of positioning node, namely, {(x,y)(rss1,rss2,...rssn)}, then use KNN algorithm to match RPs.

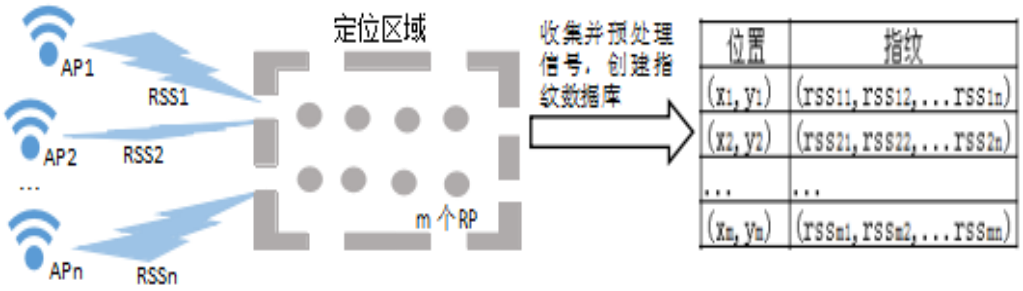

Fig.1 The establishment of the fingerprint database

The Euclidean distance between location node and the reference points could be defined as:

$$d_i = \sqrt{\sum_{j=1}^{n}\left(R_j - S_{ij}\right)^2} \tag{1}$$

Where i = 1, 2,... m, j = 1,..., n. R_j is the average signal strength namely fingerprint information which location node receives from APj. Sij is the fingerprint information in the ith reference point from APj. So we can obtain k reference position which have the minimum value of Euclidean distance by calculating and sorting d_i.

$$\left(\bar{x}, \bar{y}\right) = \frac{1}{k}\sum_{i=1}^{k}\left(x_i, y_i\right) \tag{2}$$

$\left(x_i, y_i\right)$ is the coordinates of the ith RP. So we can calculate the estimated position of locating point by type (2).

A key factor affected the accuracy of positioning in KNN algorithm is to select the reasonable value of K. This value also relates to the density of fingerprint acquisition, we can get it through several experiments. However, the largest shortage of KNN algorithm is lacking in distinguishing the weight of fingerprint, because the contribution of each RP to the anchor point is different and the impact on matching fingerprints is not the same. Against the above, this paper introduces weighted processing the standard deviation of signal strength to improve the location method and puts forward modified KNN algorithm.

2.2 Modified KNN Algorithm.

Because of the complexity of the indoor environment, the received signal strength is not stable even at the same position of different time, and the instability of signal is instantiated in the fluctuation of

signal value. Considering this factor, Modified KNN algorithm introduces standard deviation of signal strength when calculating Euclidean distance, and then give a weight to each of the K fingerprints according to the improved Euclidean distance, finally estimate the location of anchor point using K weighted location.

The improved Euclidean distance can be defined as:

$$d_i' = \sqrt{\sum_{j=1}^{n}\left(\left|R_j - S_{ij}\right| + \sigma_j\right)^2} \tag{3}$$

$$\sigma_j = \sqrt{\frac{1}{N}\sum_{p=1}^{N}\left(R_{pj} - R_j\right)^2} \tag{4}$$

Where i = 1, 2,...m, j = 1,..., n, p = 1,2,...N. N is the total number of measurements at each position. R_{pj} is the pth signal measurement from AP_j at locating position. σ_j is the standard deviation of RSS at anchor point.

According to the calculation results of d_i', we can sort them and select K minimum points, and then set right weight to K points on the basis of the size of the d_i' value. The smaller Euclidean distance indicates the greater similarity between the reference point and positioning point, so we should allocate a larger weight, otherwise a smaller weight.

So the location of locating position (x, y) can be calculated using modified KNN algorithm as follows:

$$(x, y) = \frac{\sum_{i=1}^{k} w_i (x_i, y_i)'}{\sum_{i=1}^{k} w_i} \tag{5}$$

Where i = 1, 2,...,k. $(x_i, y_i)'$ represents position coordinates of the ith RP from K nearest reference point. w_i is the weight of the ith RP. Its computation formula is as follows:

$$w_i = \frac{1}{d_i} \tag{6}$$

Judging from this, the above method could improve the indoor positioning accuracy compared with the traditional KNN method.

3. Simulation Results And Algorithm Analysis

For evaluating the performance of modified algorithm, this section use Matlab to simulate and analysis. Simulation area diagram is shown in Fig.2. the simulation area has 20 m * 15 m, which contains 100 reference position (2*1.5 m^2), and sets six wireless access point AP(randomly placed).

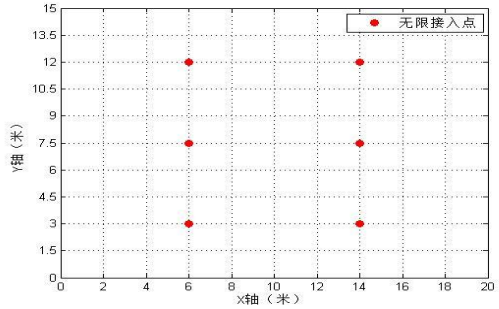

Fig.2 The simulation area

To verify that the improved Euclidean distance is better than the traditional Euclidean distance, let us contrast two data collections at the two same positions, as is shown in Table 1.

Table 1. Two sets of Euclidean distance comparation

	Rss_Avg1	Rss_Avg2	Rss_Avg1	Rss_Avg2
AP1	-89	-87	-88	-87
AP2	-75	-75	-74	-75
AP3	-77	-78	-78	-78
AP4	-83	-81	-80	-81
AP5	-74	-75	-74	-74
AP6	-85	-90	-84	-89
Traditional	17.76		17.73	
Improved	17.87		17.75	

In this table, rss_avg1 and rss_avg2 respectively are the average signal strength of two positions, the last two lines respectively express Euclidean distance of two methods. From Table 1, we can see the fluctuation of first data set is larger. It illustrates that the improved Euclidean distance is bigger along with the greater volatility. Accordingly, the weight will be smaller.

In locating phase, we respectively use KNN algorithm and modified KNN algorithm to match the fingerprint database. The positioning accuracy of both methods are related to the selection of K value, as is shown in Fig.3. The error of two algorithm decreases with the increase of K value, and the positioning error of modified KNN algorithm is obvious smaller than the traditional KNN algorithm. So it is that modified KNN algorithm is obviously better than KNN algorithm.

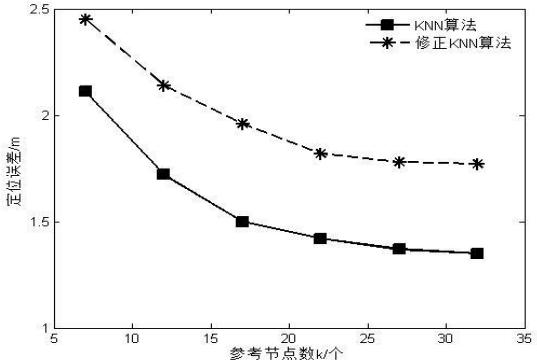

Fig.3 The positioning error statistics

4. Conclusion

This paper firstly introduces the KNN algorithm, and then on its basis put forward the modified KNN algorithm through introducing the standard deviation of signal strength. Next, simulation analysis was carried on. The experimental results show that the modified KNN algorithm further improve the precision of positioning. But deficiency is that the workload to establish a fingerprint database is too heavy in offline stage. So how to balance the fingerprint integrity and great work or finding a fingerprint automatic measurement method, is research content on next stage.

Acknowledgements

This paper is supported by Sichuan Applied Basic Research Fund (The Research of Remote Intelligent Interaction Education Platform 15226618)

References

[1] Kaplan, E.D.; Hegarty, C. Understanding GPS: Principles and Applications, 2nd ed.; Artech House: Norwood, MA, USA, 2006.

[2] KAEMARUNGSI K,KRISHNAMURTHY P. Properrties of Indoor Received Signal Strength for WLAN Localtion Fingerprinting[C]//Proceedings of the First Annual International

Conference on Mobile and Ubiquitous Systems: Networking and Services (MobiQuitous'04). Massachusetts: IEEE, 2004: 14-23.
[3] Alavi B,Pahlavan K.Modeling of the TOA-based distance measurement error using UWB indoor radio measurements[J].Communications Letters,IEEE,2006,10(4):275-277.
[4] Curran K,Furey E,Lunney T,et al.An evaluation of indoor location determination technolagies[J]. Journal of Location Based Services,2011,5(2):61-78
[5] Z.H. Cai, X. Xia, B. Hu, D.M. Fan: Improvement of indoor signal strength fingerprint location algorithm, Computer Science, Vol.41 (2014) No.11, p.178-181. (In Chinese)
[6] M. Yang, C.D. Xiu, K. Zou, D.K. Yang.A Sensing Probability-based Matching Algorithm for WiFi Indoor Positioning Systems[J].Global Positioning System,2013(6):7-11.
[7] W.X.Zhang. The Fingerprint Location Algorithm Based on RSSI of WiFi[D].University of Electronic Science and Technology of China.2015.